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COMPONENTS OF PHENOTYPIC VARIABILITY FOR HEAD DIAMETER IN SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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Sunflower is the main crop species for the production of edible oil in many countries of the world, including ours. Plant height and head size, form and position on the stem as well as the number of leaves, their size, duration and distribution on the plant all play an important role in defining optimal plant architecture in sunflower hybrids (ŠKORIĆ, 1975, 1989, 2002). In order to monitor the mode of inheritance and gene effects for head diameter in the F_1 and F_2 generations, half diallel crosses were made in six genetically divergent sunflower inbreds. The mean values of the trait in question differed significantly. The mode of inheritance of head diameter in the F_1 generation was superdominance in all but four crosses, which had dominance instead. In the F_2 generation, on the other hand, the prevailing mode was dominance, while superdominance was recorded in four cases. The dominant component accounted for the bulk of genetic variance, and the mode of inheritance of head diameter taking into account both the F_1 and F_2 generations was superdominance. These findings may prove valuable for developing high-yielding sunflower genotypes.

Key words: sunflower, inbred lines, mode of inheritance, gene effect, simple correlation coefficient

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INTRODUCTION

The sunflower is the main oil crop in many countries including Serbia and Montenegro. This is why emphasis in breeding for yield is placed on high seed production per plant. This is achieved by developing hybrids that combine high genetic yield potential, desirable plant architecture, tolerance to diseases and adaptability to specific agroecological conditions.

ALBA *et al.* (1979), GIRARAJ *et al.* (1979) and MARINKOVIĆ (1987) reported significant direct effects of head diameter on seed yield. Indirect effects of head diameter on seed yield were reported by AHMAD *et al.* (1991).

Numerous researchers (ŠKORIĆ, 1975; IVANOV, 1980; MARINKOVIĆ, 1992; SUZER and ATAKISS, 1993; PETAKOV, 1994; PUNIA and GILL, 1994) have found significant positive correlations between morphological characteristics such as head diameter and seed yield.

By changing the hybrid model it is possible to increase the competitiveness of sunflower plants. Such plants will be able to produce more than 1,500 seeds per head when grown in a dense stand, i.e., they will be able to achieve high and stable seed yields and oil contents. A yield component that directly changes hybrid model is head size which is expressed as head diameter in cm. Head size should be intermediate, with a diameter of 20-25 cm, thin and with firm epidermis underside (ŠKORIĆ, 1980). Increase in head size above the optimum value results in reduced kernel yield (g/head), increased husk percentage, increased number of empty seeds and reduced oil content in seed (ŠKORIĆ, 1989).

In addition to genetic factors, head size is also affected by environmental factors (soil moisture and fertility, number of plants per unit area) and the length of growing season (MARINKOVIĆ *et al.*, 2003). FICK (1978) concluded that the contribution of genetic factors in the inheritance of head diameter is lower than for most of the other agronomic character.

Significant effect of plant population on head diameter (r=-0.89**) was reported by MICHELE *et al.* (1996). Increased row distance tends to increase head diameter (ESENDAL and KANDEMIR, 1996).

Investigations on the inheritance of head diameter conducted so far have provided different results. The results varied in dependence of the material used for crossing. KOVAČIK and ŠKALOUD (1971), VOLF and DUMANČEVA (1973), SEETY *et al.* (1977), MARINKOVIĆ (1984), ŠEĆEROV-FIŠER (1992), KUMAR (1998) and JOKSIMOVIĆ *et al.* (2000) found that the non-additive genetic variance prevailed in the inheritance of head diameter. Conversely, PUTT (1965), KOVAČIK and ŠKALOUD (1972), RAO i SING (1977), SINDAGI *et al.* (1979), DUA *et al.* (1985), MARINKOVIĆ and ŠKORIĆ (1990) and EL-HITY (1992) reported that that the additive component of genetic variance prevailed over the non-additive.

To efficiently use the available breeding material, it is necessary to have knowledge of its genetic makeup and of the mode of inheritance of the characteristic bred for (KRALJEVIĆ-BALALIĆ, 1986).

The objectives of this investigation were to assess the mode of inheritance of head diameter in the F_1 and F_2 generations of sunflower and to evaluate gene effects and the relationship between head diameter and seed yield per sunflower plant

MATERIAL AND METHOD

To assess the mode of inheritance and gene effects for sunflower head diameter, six genetically divergent inbred lines ($OCMS_1$, NS-204B, NS-22B, NS-BD, NS-NDF, NS-K), developed at Institute of Field and Vegetable Crops in Novi Sad, were diallelly crossed, without reciprocals, to produce the F_1 and F_2 generations. The experiment was then established in the random blocks system in three replicates in the location of Rimski Šančevi. The experiment included the six inbred lines, 15 F_1 and 15 F_2 hybrids. Samples for analyses were taken from inner rows, excluding border rows. The samples of the parent lines and the F_1 generation consisted of five plants per replicate, of the F_2 generation of 30 plants per replicate. Measurements of the analyzed characteristic were done in the field, at maturity stage.

Mean values and correlation coefficient r, as an indicator of mutual interdependence between the two variables, were calculated according to HADŽIVUKOVIĆ (1991).

To assess the mode of inheritance for head diameter, we tested the significance of the mean values of the F_1 and F_2 generations in relation to the parents' mean (BOROJEVIĆ, 1965).

To assess gene effects for the studied characters, the combining ability of the diallel crosses according to GRIFFING (1956), method 2, model I were analyzed.

Genetic variances were assessed by the method of MATHER and JINKS (1982).

RESULTS AND DISCUSSION

The inbred lines and their F_1 and F_2 hybrids differed significantly in the mean values for head diameter and yield per plant (Table 1). The smallest diameter was found in line NS-NDF (16.3 cm), the largest in line $OCMS_1$ (21.2 cm). The lowest mean values in the F_1 and F_2 generations were found in combination NS-22BxNS-NDF (19.4 cm and 18.2 cm, respectively), the highest in combination $OCMS_1$xNS-BD (24.1 cm and 23.8 cm, respectively), Table 1.

In the F_1 generation, four combinations inherited head diameter dominantly from the parent with the larger mean value, while positive heterosis occurred in 11 combinations (Table 1).

In the F_2 generation, dominance of the parent with the larger mean value was registered in 11 combinations, and positive heterosis was exhibited in the following combinations: $OCMS_1$xNS-204B, $OCMS_1$xNS-BD, NS-22BxNS-K and NS-NDFxNS-K (Table 1). Dominance and superdominance was stated in the inheritance of head diameter (MOROZOV, 1947; SCHUSTER, 1964; KOVAČIK i ŠKALOUD, 1971; STOJANOVA *et al*., 1971; MARINKOVIĆ, 1984).

Table 1. Mean values for head diameter (cm) and seed yield per plant

Parents and hybrids		Head diameter	Seed yield per plant
		cm	g
P_1	$OCMS_1$	21.2	43.3
F_1	$OCMS_1$xNS204B	24.1^{h}	88.6
F_2		23.3^{h}	81.6
F_1	$OCMS_1$xNS22B	22.9^{h}	91.0
F_2		21.9^{d+}	53.1
F_1	$OCMS_1$xNSBD	24.1^{h}	100.7
F_2		23.8^{h}	71.9
F_1	$OCMS_1$xNSNDF	22.3^{h}	78.3
F_2		21.5^{d+}	63.8
F_1	$OCMS_1$xNSK	22.2^{h}	105.2
F_2		21.5^{d+}	76.2
P_2	NS204B	19.5	44.36
F_1	NS204BxNS22B	21.9^{h}	102.5
F_2		20.4^{d+}	51.4
F_1	NS204BxNSBD	22.3^{h}	110.1
F_2		20.8^{d+}	48.4
F_1	NS204BxNSNDF	20.8^{d+}	81.3
F_2		20.0^{d+}	48.4
F_1	NS204BxNSK	21.2^{h}	109.7
F_2		20.7^{d+}	65.2
P_3	NS22B	18.2	47.2
F_1	NS22BxNSBD	21.1^{d+}	90.2
F_2		20.5^{d+}	56.8
F_1	NS22BxNSNDF	19.4^{d+}	95.1
F_2		18.2^{d+}	41.4
F_1	NS22BxNSK	21.1^{h}	110.8
F_2		20.0^{h}	70.0
P_4	NSBD	20.7	43.6
F_1	NSBDxNSNDF	22.3^{h}	92.2
F_2		21.4^{d+}	56.8
F_1	NSBDxNSK	22.5^{h}	128.9
F_2		21.7^{d+}	76.3
P_5	NSNDF	16.3	24.8
F_1	NSNDFxNSK	20.8^{h}	115.4
F_2		20.2^{h}	69.0
P_6	NSK	17.4	29.7

The analysis of the components of genetic variance showed that the dominant component (H_1 and H_2) was larger than the additive one (D) for head diameter. It means that the dominant component makes the main portions of genetic variance in the F_1 and F_2 generations (Table 4). These results are in agreement with those of KOVAČIK and ŠKALOUD (1971), VOLF and DUMANČEVA (1973), SEETY *et al.* (1977), MARINKOVIĆ (1984) ŠEĆEROV-FIŠER (1992), KUMAR *et al.* (1998) and JOKSIMOVIĆ *et al.* (2000), but they are contrary to the results of PUTT (1965), KOVAČIK and ŠKALOUD (1972), RAO and SING (1977), SINDAGI *et al.* (1979), DUA *et al.* (1985), MARINKOVIĆ and ŠKORIĆ (1990) and EL HITY

(1992) who maintained that the additive component was more important that the dominant one in the inheritance of head diameter in sunflower.

As the F value was positive, it may be concluded that dominant genes prevail over recessive ones in the expression of this characteristic in the studied inbred lines. This was fully confirmed by the calculated gene frequencies. The frequency of dominant (u) genes was higher than the frequency of recessive (v) genes. Dominant (u) and recessive (v) genes were not evenly distributed among the parents as indicated by the ratio ($H_2/4H_1$) which was different from 0.25 (Table 2).

The calculated value of $(H_1/D)^{1/2}$, which shows the average degree of dominance, was larger than one. This was an indication that superdominance was exhibited in the inheritance of head diameter when all combinations in the F_1 and F_2 generations are taken into account (Table 2).

The ratio of the total numbers of dominant versus recessive genes for all parents showed that dominant genes prevailed since the values of Kd/Kr were larger than one in both generations (Table 2).

Table 2. Variance components for head diameter per sunflower plant

Component	Head diameter **Value**	
	F_1	F_2
D	3.61	3.62
H_1	7.61	5.01
H_2	7.43	4.64
F	0.24	0.20
E	0.03	0.02
$H_2/4H_1$	0.24	0.23
u	0.58	0.65
v	0.42	0.35
$(H_1/D)^{1/2}$	1.45	1.18
Kd/Kr	1.05	1.05

The interdependence between head diameter and seed yield per plant was found to be positive and highly significant (0.601**), tab.3. That is in agreement with the results of (ŠKORIĆ, 1975; IVANOV, 1980; MARINKOVIĆ, 1992; SUZER and ATAKISS, 1993; PETAKOV, 1994; PUNIA and GILL, 1994).

Table 3. Correlation coefficient for head diameter and seed yield per plant

Characteristic	Head diameter	Seed yield per plant
Coefficient r	0.621**	

** Significant at LSD 1%

This investigation may be useful in sunflower breeding for high genetic yield potential because it was found that the parents included into the diallel possessed a large number of dominant genes for head diameter while highly significant interdependence was found between this parameter and seed yield per plant.

CONCLUSION

A diallel cross excluding reciprocals has been made in order to assess the mode of inheritance and gene effects for head diameter in the F_1 and F_2 generations of sunflower.

The mean values of the tested lines and hybrids differed significantly for the characteristics studied.

Head diameter was inherited dominantty and superdominantt in F_1 i F_2.

The analysis of components of variance showed that dominant genes prevailed over recessive ones in the expression of head diameter, i.e., the major part of genetic variance was due to the dominant gene action.

The existence of superdominance in the inheritance of head diameter was confirmed by the average degree of dominance which was larger than unity.

This investigation may be important for further work because sunflower breeding for yield components based on heterosis should make use of crosses which exhibit non-additive gene effect (dominance and epistasis).

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KOMPONENTE FENOTIPSKE VARIJABILNOSTI ZA PREČNIK GLAVE SUNCOKRETA

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Izvod

Suncokret je u mnogim zemljama u svetu i kod nas osnovna biljka za proizvodnju jestivog ulja. Visina biljke, veličina, forma i položaj glave na stablu, broj listova, njihova veličina, trajanje i raspored na biljci imaju važnu ulogu u definisanju optimalne arhitekture hibrida suncokreta (ŠKORIĆ, 1975; 1989; 2002). U cilju praćenja načina nasleđivanja i efekta gena prečnika glave suncokreta u F_1 i F_2 generaciji izvršena su dialelna ukrštanja isključujući recipročna sa šest genetski divergentnim inbred linijama suncokreta. Dobijene su značajne razlike u srednjim vrednostima za ispitivano svojstvo. Prečnik glave se u F_1 generaciji nasleđivao superdominantno jedino se u četiri ukrštanja javila dominacija, dok se u F_2 generaciji nasleđivao dominantno, a superdominacija se zadržala u četiri kombinacije. Glavni deo genetske varijanse čini dominantna komponenta, a način nasleđivanja prečnika glave je superdominacija uzevši u obzir sve kombinacije ukrštanja u obe generacije (F_1 i F_2). Ova istraživanja mogu biti od značaja u stvaranju visoko prinosnih genotipova suncokreta.

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